(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 417 510 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
02.04.2008 Bulletin 2008/14

(21) Application number: **02754774.4**

(22) Date of filing: **27.06.2002**

(51) Int Cl.:
G01S 13/00 *(2006.01)* ***G01S 13/87*** *(2006.01)*

(86) International application number:
PCT/EP2002/007115

(87) International publication number:
WO 2003/014764 (20.02.2003 Gazette 2003/08)

(54) **METHOD OF DETERMINING THE POSITION OF A TARGET USING TRANSMITTERS OF OPPORTUNITY**

METHODE ZUR POSITIONSBESTIMMUNG EINES OBJEKTS MITTELS ZUR VERFÜGUNG STEHENDER SENDER

PROCEDE PERMETTANT DE DETERMINER LA POSITION D'UNE CIBLE AU MOYEN D'EMETTEURS OPPORTUNISTES

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR

(30) Priority: **03.08.2001 GB 0118993**

(43) Date of publication of application:
12.05.2004 Bulletin 2004/20

(73) Proprietor: **ROKE MANOR RESEARCH LIMITED**
Romsey,
Hants SO51 0ZN (GB)

(72) Inventors:
- **ATKINSON, Simon, John**
  Hants SO51 7JR Romsey (GB)
- **BAKER, Adam, Alexander**
  Hants SO40 7QA Southampton (GB)
- **RICKETT, Bryan, Stephen**
  Hampshire, SO51 7LL Romsey (GB)
- **SMITH, Christopher Nigel**
  Romsey
  Hants SO51 7RJ (GB)
- **WEEDON, Robert John**
  Romsey
  Hampshi re SO51 7DB (GB)

(74) Representative: **Morgan, Marc et al**
Siemens Corporate Shared Services
Siemens AG
P.O. Box 22 16 34
80506 Munich (DE)

(56) References cited:
WO-A-01/22117
US-A- 5 410 314
US-B1- 6 232 922

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 417 510 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The use of radars to detect the position of moving objects is well known. It has also been previously proposed to detect the position of a target using so called "transmission of opportunity" wherein receivers detect transmissions, reflected from a target, originating from a transmitter. However in such systems, a direct line of sight of the receiver to the transmitter must also be provided (or a cable connection is needed) in order to create a reference in the receivers which can then be used for correlation with the delayed signal arriving via reflection from a target.

[0002] In certain telecommunication systems, transmitters use pre-stored codes as part of their modulation protocol. The inventors have determined that these codes can be advantageously used as templates for a correlator when correlating signals from a receiver reflected from a target in order to provide timing information to assist target location. This enables a method of detecting target positional information which obviates the need to have a direct line of sight from the receiver

[0003] The invention comprises in a communication system wherein pre-stored codes are used in transmissions as part of the communication protocol, a method of determining the position of a target comprising the steps of: providing a transmitter to transmit a signal to the target, providing a plurality of receivers, in communication with each other, to receive signals reflected from said target, the receivers being time or phase synchronised; determining the time of arrival information of said code of reflected signal at each receiver by continuously correlating said received signal with the pre-stored codes in the receiver; using information pertaining to the position of each receiver and with the information obtained, determining the target position.

[0004] An example which is not part of the invention also includes in a communication system wherein pre-stored codes are used in transmissions as part of the communication protocol, a method of determining the position of a target comprising the steps of: providing a plurality of transmitters to transmit each a signal to the target, said transmitters being time or phase synchronised, providing a receiver to receive signals reflected from said target and wherein said signals are sent out pre-set times known to the receiver; correlating said received signal with the pre-stored codes in each receiver to identify the transmitter of a particular signal; the receiver determining the time delay in receiving said signal by subtracting the time of arrival of a pre-stored code of each reflected signal from each transmitter from the known time the pre-stored code was sent, using information known to the receiver pertaining to the position of each transmitter and the with the timing information obtained, determining the target position

[0005] Transmitters in many current communications systems are using pre-stored codes as part of their modulation protocol (e.g. for the purposes of channel equalisation or signal identification).The invention makes use of these pre-stored codes in a number of ways to detect the position of a target, where signals from transmitter(s) are reflected from the target to receivers. At the receivers detection of the codes by correlation allows the receiver to detect when the embedded code is received. This along with other information, such as transmitter or receiver location, enables target location to be determined. One main embodiment uses known information of when the codes are sent to provide useful timing information; this is because some codes are sent out at pre-determined time from a transmitter, these times also being known by a receiver.

[0006] In some systems, the codes will also include a unique identification of a particular transmitter and a receiver may look up the location; i.e. the base station identity, contained within the signal can also be used in order to help sort out where each transmission came from. This eliminates any identification problems with respect to different signals from different base stations containing the same information producing correlations. In known telecommunication systems it is known to include a modulated or coded portion unique to the transmitter.

Preferred embodiment

[0007] In this embodiment there is a single transmitter and a number of receivers. An example may be a transmitter used in mobile communications. The transmitted signal includes one or more codes which are used in the protocol(s). A signal is transmitted and will be reflected from a target such as an aircraft to a plurality of receivers. Each receiver has the code pre-stored and continuously correlates this code with the received signal. When there is a peak in the correlation, the time T(i) is noted by each receiver i. These times are then sent to a processor, which may be located in one of the receivers. The processor used the times that the code was received and known information as to the positions of the receivers to calculate the position of the target. It is to be noted that such a system relies upon the code signal portion being defined within the protocol standard for the transmission type and as such is well defined and does not change. Also it is worth mentioning that the absolute time taken between transmission and reception of signal does not have to be known, just the (relative) times at each receiver when the reflected signal is received is important.

[0008] In other words the position where the correlation peak occurs will indicate the time at which that signal was received with respect to the reference template. This is especially useful when time difference of arrival techniques are used because in this case the absolute time that the transmission was sent is irrelevant, it is the relative time between signals (sent from the same location) arriving at different receiver locations that reveals the target position.

It would be clear to a person skilled in the art how the resultant data can be used to determine target position

e.g. triangulation.

[0009] Because the codes are known to be within the waveform by design, it is not now necessary to record those codes via a direct link to the transmitter. The codes are pre-ordained and as such may be pre-programmed into every receiver, thereby allowing the cross correlation process to occur irrespective of the data content of the specific transmitted signal. The receivers need to be synchronised.

Example

[0010] In this example there are a plurality of transmitters and a single receiver. The transmitters are synchronised. Each transmitter will send a signal which is received by the receiver. The receiver will again correlate incoming signals with a pre-stored code, and will make a note of the time that the prestored code is received for each transmitter. However in this case the absolute time between transmission and the reflected signal from the target being received is determined. The method makes use of the fact that embedded codes used in a protocol is in a fixed (known position) within the transmitted signal and the transmitter transmits at pre-set times (known to the receiver also). Thus if clocks of the transmitters are synchronised with that of the receiver the absolute time difference between signal sent and received (reflected via the target) can readily be determined by the receiver for each transmitter signal. With known data on the location of the transmitters the receiver can determine the target location.

[0011] In the example of a modem 3G cell phone systems use fully time synchronised networks so that every base station has a predetermined series of time and frequency slots when it transmits. If the receivers are then synchronised to the cellular network they know which base station has transmitted to within the accuracy of the synchronisation scheme 1 or 2 seconds. Now when the correlation process determines the time of arrival of the transmitted signal reflected from the target (in the same way as before) it can subtract the known transmission time to reveal the time of flight of the reflected signal. This time of flight information places the target on a locus that links all the positions where the range of the target with respect to the transmitter and receiver positions is a constant. To resolve the position on this locus of the target a second locus , with a different transmitter position is needed. Now the intersection of these loci defines the target position. Clearly, where signal reflections from multiple transmitter are received the estimate of target position becomes more accurate.

[0012] In a preferred embodiment, the signal from each transmitter preferably has unique identifying data so the receiver can discriminate the reflected signals in respect of which transmitter they came from. This reduces the number of parameters required such as the number of receivers/and or transmitter required for input to calculate position. Furthermore, if the receiver has pre-stored the geometric location of the identified transmitters i.e. the relative positions of the transmitters are known, the position of the target can be determined more readily.

[0013] Of course there are a number of different permutations and combinations which fall within the scope of the invention which would be clear to the skilled person.

[0014] In some instances it may be necessary where the transmitter is continuously sending out signals, for the receivers to discriminate between successive signals so that they are assessing the same signal, i.e. sent out at the same time.

[0015] Naturally the system may comprise of a plurality of receivers and a plurality of transmitters. Although the calculation of such a hybrid system would be more involved it would be clear to the skilled mathematician how the data can be used.

[0016] Furthermore the inventor has determined that current mobile telecommunications networks lend themselves very well to implement the above methods. The system is well adapted to use standard mobile telephone transmissions because of the aforementioned pre-stored codes used in mobile phone transmissions. For example in mobile phone modulation protocol there are included unique base station identification data and so called "training sequences" which are advantageously used in determination of target position. A GSM network operates typically with 200KHz channels. Training codes (also called mid-amble) which are 26 bits long occur in every package i.e. every 660 microseconds. It is these codes that are used as the correlator reference in each receiver.

[0017] In one example of the invention standard telephone receivers are used and the received signal that is fed to an A/D converter occupying 200KHz bandwidth is demodulated and the data package segmented into its training sequence and base station ID sequence. The training sequence is fed forward for correlation with the pre-stored training sequence in order to determine the time of arrival of the transmission. The base station identification is decoded and the bases station position can be determined (via pre-surveyed information for example), if this is needed for a particular implementation.

Claims

1. A method of determining the position of a target, adapted to be used in a communication system wherein pre-stored codes are used in transmissions as part of the protocol, comprising the steps of:

   a) providing a transmitter of the communication system to transmit a signal to the target,
   b) providing a plurality of receivers, in communication with each other, to receive signals reflected from said target, the receivers being time or phase synchronised;
   c) determining the time of arrival information of said code of reflected signal at each receiver by

continuously correlating said received signal with the pre-stored codes in the receiver;
d) using information pertaining to the position of each receiver and with the information obtained from step c), determining the target position.

2. A method as claimed in claims 1 wherein the transmitter signals include a modulated or coded portion unique to the transmitter which is used to identify the transmitter and hence its location for step (d).

3. A method as claimed in claim 1 or 2 wherein the receivers communicate said time of arrival information and a receiver identification to a processor.

4. A method as claimed in claim 4 wherein said processor is located in one of the receivers.

5. A method as claimed in any preceding claim wherein said signal includes the mid-amble or a portion thereof or any unique sequence of data that is known to the receiver before transmission.

Patentansprüche

1. Ein Verfahren zur Bestimmung der Position eines Zielobjekts, welches für den Einsatz in einem Kommunikationssystem ausgelegt ist, bei dem vorab gespeicherte Codes bei Übertragungen als Bestandteil des Kommunikationsprotokolls verwendet werden, und das folgende Schritte umfasst:

a) Bereitstellen eines Senders des Kommunikationssystems für die Übertragung eines Signals an das Zielobjekt;
b) Bereitstellen einer Mehrzahl von Empfängern, die miteinander kommunizieren, um Signale zu empfangen, welche von besagtem Zielobjekt reflektiert werden, wobei die Empfänger zeit- oder phasensynchron arbeiten;
c) Bestimmen der Ankunftszeit des besagten Codes des reflektierten Signals an jedem Empfänger durch kontinuierliches Korrelieren des besagten Empfangssignals mit den vorab gespeicherten Codes im Empfänger;
d) Verwenden von Informationen zur Position eines jeden Empfängers und, anhand der in Schritt c) erhaltenen Informationen, Bestimmen der Zielposition.

2. Ein Verfahren gemäß Anspruch 1, bei dem die Sendersignale einen modulierten oder codierten Signalanteil beinhalten, welcher für den Sender eindeutig ist und der in Schritt (d) verwendet wird, um den Sender selbst und somit auch dessen Standort zu identifizieren.

3. Ein Verfahren gemäß Anspruch 1 oder Anspruch 2, bei dem die Empfänger die besagte Ankunftszeitangabe sowie eine Empfängerkennung an einen Prozessor übermitteln.

4. Ein verfahren gemäß Anspruch 4, bei dem sich der besagte Prozessor in einem der Empfänger befindet.

5. Ein Verfahren gemäß einem der vorstehenden Ansprüche, bei dem das besagte Signal die Trainingssequenz (Midamble) oder einen Teil davon oder irgendeine eindeutige Datenfolge beinhaltet, die empfängerseitig bereits vor der Übertragung bekannt sind.

Revendications

1. Procédé pour déterminer la position d'une cible, adapté pour être utilisé dans un système de communication dans lequel des codes stockés au préalable sont utilisés pendant des émissions comme partie du protocole, comprenant les étapes consistant à :

a) réaliser un émetteur du système de communication pour émettre un signal vers la cible ;
b) réaliser une pluralité de récepteurs, en communication les uns avec les autres, pour recevoir des signaux réfléchis par ladite cible, les récepteurs étant synchronisés en temps ou en phase ;
c) déterminer les informations sur l'heure d'arrivée dudit code du signal réfléchi au niveau de chaque récepteur en corrélant continuellement ledit signal reçu avec les codes stockés au préalable dans le récepteur ;
d) utiliser les informations relatives à la position de chaque récepteur et, avec les informations obtenues à l'étape c), déterminer la position de la cible.

2. Procédé selon la revendication 1 dans lequel les signaux de l'émetteur comprennent une partie modulée ou codée propre à l'émetteur qui est utilisée pour identifier l'émetteur et, par conséquent, son emplacement pour l'étape (d).

3. Procédé selon la revendication 1 ou 2 dans lequel les récepteurs communiquent lesdites informations sur l'heure d'arrivée et l'identification d'un récepteur à un processeur.

4. Procédé selon la revendication 4 dans lequel ledit processeur est situé dans l'un des récepteurs.

5. Procédé selon l'une quelconque des revendications

précédentes dans lequel ledit signal comprend le bloc de données d'apprentissage (mid-amble) ou une partie de celui-ci ou toute séquence unique de données qui est connue du récepteur avant l'émission.